Winter 11-24-2020

Scientometric Analysis of Citation Impact of Six Indian Institutes of Technology during 2006-2015

banalata pradhan Mrs
bnp.iter@gmail.com

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Banalata Pradhan

Assistant Librarian, SOA University, Odisha, India. E-mail: bnp.iter@gmail.com

Abstract: The study analyzed 72940 papers indexed by Scopus and published by six Indian Institutes of Technology (IIT Delhi, IIT Kharagpur, IIT Madras, IIT Bombay, IIT Kanpur and IIT Roorkee) during the period 2006-2015, which indicates that 72940 papers received 572583 citations in all during the period 2006-2015 in an average rate of citation per paper for six IITs is 7.85. Highest 4 authors are from IITKGP, followed by 3 authors each from IITR, IITD and IITB are highly cited by others. It evident that the output of six IITs is well connected with prime channel science as more than four fifth of the published papers were appeared in standard, high and very high impact factor journals.
Keywords: Citation analysis, Citation Impact, Research Papers, Scientometrics and Indian Institutes of Technology

1. Introduction:

Given the importance of science and technology in the economic and manufacturing development, the country has invested heavily in developing infrastructure for R&D in the frontier areas, such as, space sciences, electronics, telecommunication, atomic energy and more recently in biotechnology, over the years. Science and technology has been recognized as the pivotal role of our S&T system by the Government policy in uplifting the quality of life of the people, particularly the deprived sections of the society, in generating wealth for all, in building India globally antagonistic, in mobilizing natural resources in a imperishable manner, in safeguarding the environment and make sure national security. Because Science and Technology (S&T) are complementary in the knowledge domain, wherein science exemplifies discovery and knowledge creation, and technology exemplifies innovations using knowledge. The benefits of science are delivered to the people and society through the mechanism of technology.

The Indian Institutes of Technology (IITs) have been recognized as the peninsula of perfection in the orbit of higher education in India. Initiated as a contraption in technological education apart from the stereotyped university system, the number IITs have increased from the five IITs ingrained during the period 1950–63 to 23 in 2016. All over the world, degrees accorded by IITs are acknowledged and esteemed. In March 1946, the 22-member committee recommended for the establishment of four technical institutes to make essential enthusiasm and adaptability of organization in light of augmenting knowledge in a wavering society. After taking the assistance

from international organizations or foreign governments initially four of the five IITs were established. The primeval IIT was established in May 1950 in Kharagpur, near Calcutta, followed by IIT Bombay in 1958, Madras in 1959, and Kanpur in 1959. By an act of 1961 known as Institutes of Technology Act, these institutes were entitling as "institutions of national importance." By an amendment to the 1961 act, the College of Engineering, established in New Delhi in 1961, was also re title IIT Delhi in 1963. The sixth IIT i.e. IIT Guwahati was established in 1994 followed by IIT Roorkee in 2001 was assimilated into the IIT system, becoming the seventh IIT. As a result, in 2001, there were seven institutes under the IIT system are incorporated. Currently 23 IITs are working all over India. Among the technological institutes in the country, the IITs produce the major portion of Ph Ds in engineering and also the largest contributions of scientific articles every year. These institutes were modeled on the Massachusetts Institute of Technology, USA. But in due course of time, the working of the IIT system began to mimic that of the EcolePolytechniques of France.

2. Objective of the study

- To diagnose the type of documents used for communicating research results;
- To investigate the distribution of citation pattern and to identify highly cited authors;
- To recognize the common journals in which most of the research results are published.

3. Literature Review

Several studies in the past have been published in literature dealing with the research performance of countries, different subjects and institutions. For example, Saxena, Gupta and Jauhari[1] evaluated and compared the application of h-index, g-index, and p-index on 40 Indian engineering and technological institutes and accordingly ranked them. Siddaiahet al[2] analyzed the contribution and citation impact of eight new IITs during 2010-14 which indicate significant differences in publication pattern of new IITs. Singh, Gupta & Kumar[3]used various quantitative and qualitative indicators and suggested a methodology for getting an idea about the relative performance of various subject fields of IIT Roorkee from 1993 to 2001. Pradhan and Ramesh analyses 5378 papers published by Indian Institute of Technology Madras and 4430 papers published by Indian Institute of Technology Bombay in the field of Engineering Sciences and its sub-field during 2006–2015.[4] The result shows that although the annual rate of growth is

inconsistent during the period of study, but the productivity grew continuously throughout the study period.

4. Type of documents used for disseminating research results

The selection of an appropriate outlet often has an influence on the visibility and impact of the published research. Hence, analyses of the types of document used for communicating research results are very important. The results of the analysis on the type of documents used by six IITs for publishing research results are given in Table 4.1. It indicates that the scholars from all the six IITs preferred to publish their research results as the journal article followed by conference papers, reviews, book chapters, letters and notes in that order. Data presented in Table 1 indicates that about 70% of the output was published as journal articles. The proportion of journal papers was almost equal for IITR and IITKGP closely followed by IITK. Among all the six IITs, IITB published highest (29.89%) papers as conference papers followed by IITD (27.59%).

Table 4.1 Type of documents used for disseminating research results

Document Type	IITD	IITKGP	IITM	IITB	IITK	IITR	Total
Articles	9472 (67.2%)	11267 (74.3%)	8548 (69.9%)	8008 (66.8%)	7401 (72.3%)	6845 (74.5%)	51541 (70.7)
Conference papers	3892 (27.6%)	3399 (22.5%)	3351 (27.4%)	3587 (29.9%)	2503 (24.5%)	1976 (21.5%)	18708 (25.7)
Reviews	386 (2.8%)	273 (1.8%)	183 (1.5%)	241 (2.6%)	182 (1.8%)	237 (2.6%)	1502 (2.1)
Book Chapters	274 (1.9%)	164 (1.1%)	113 (0.9%)	124 (1.03%)	98 (0.9%)	85 (0.9%)	858 (1.2)
Letters	57 (0.5%)	36 (0.3%)	18 (0.2%)	12 (0.2%)	13 (0.2%)	15 (0.2%)	151 (0.3)
Notes	23 (0.2%)	34 (0.3%)	19 (0.2%)	26 (0.3%)	42 (0.5%)	36 (0.4%)	180 (0.3)

Total	14104	15173	12232	11998	10239	9194	72940 (100)

4.2 Citation Analysis

Citations can be used to investigate scholarly communication and to map knowledge export and import. Indicators, such as numbers of publications or citations, are easily compared and they can be produced relatively quickly, whereas peer review takes a long time (when done thoroughly) and can therefore be expensive. Thus, as Bornmann and Leydesdorff[5] (2014) wrote "quantitative procedures can provide important information for quality assessment when it comes to comparing a large number of units, such as several research groups or universities, as individual experts are not capable of handling so much information in a single evaluation procedure."

As Ziman observes, "a scientific paper does not stand alone; it is embedded in the 'literature' of the subject."[6] A reference is the acknowledgment that one document gives to another; a citation is the acknowledgment that one document receives from another[7]. In general, a citation implies a relationship between a parts or the whole of the cited document and a part or the whole of the citing document.[8] Citation analysis is that area of bibliometrics which deals with the study of these relationships. Bibliographic citations comprise a discreet record of the influence and value of scientific publications.

A more fundamental limitation of using citations for research assessment is that it restricts the assessment to authors of peer reviewed journal articles (in research evaluation these are again most often limited to those that are indexed by the Web of Science) that receive citations, neglecting therefore publications that are not cited but that may 30 Altmetrics for Information Professionals still have had an impact (MacRoberts & MacRoberts, 2010)[9] and also neglecting any other types of research activities that may have also had some impact on the scientific community or on the general public.

A highly cited work is one that has been found useful by a relatively large number of people, or in a relatively large number of experiments. The citation count of a particular piece of scientific

work does not necessarily say anything about its elegance or its relative importance to the advancement of science or society. The only responsible claim made for citation counts as an aid in evaluating individuals is that they provide a measure of the utility or impact of scientific work. They say nothing about the nature of the work, nothing about the reason for its utility or impact. (Garfield[10], 1979, p. 246)

What Garfield established was nothing other than a safe mechanism. A citation indicates that a cited work has been referred to, and used by, a citing work-nothing more, nothing less. He expressly avoided claiming any other correlation between citations and the world-a clever move in light of the error problem.

According to Baird and Oppenheim[11], 1994 "citation studies remain a valid method of analysis of individuals', institutions', or journals' impact, but need to be used with caution and in conjunction with other measures."

The impact of research can be assessed by making citation counts of the articles received over a period of time. Table 4.2 presents the distribution of citations received by papers during 2005–2015 of six IITs. It indicates that 72940 papers received 572583 citations in all during the period 2006-2015. Thus the average rate of citation per paper for six IITs is 7.85. Out of the total papers published by the scientists of six IITs, more than one-third of Papers (4940) of IIT Delhi, 3472 papers of IITKGP, 3460 papers of IITM, 3215 papers of ITB, 2564 papers of IITK and 2596 papers of IITR did not get any citations.9164 papers of IITD, 11701 papers of IITKGP, 8772 papers of IITM, 8783 papers of IITB, 7675 papers of IITK and 6595 papers of IITR cited one or more than one times. It has been observed from the table that most of the papers of six IITs are cited between 11-20 citations, i. e 11.93%. The proportion of papers receiving citations more than 50 citations is very low i.e. 2.25%. The number of papers received citations more than 100 is highest for IITR. Based on the pattern of citations it can be concluded that the Indian scientific output is connected to the mainstream science as about three fourth of the papers were cited one or more times. The average citation per paper is 7.85 for all the six IITs.

Table 4.2 Citation pattern of output of six IITs during 2006-2015

Extent of citations	TNP IITD	TNC	TNP IITKGP	TNC	TNP IITM	TNC	TNP IITB	TNC	TNP IITK	TNC	TNP IITR	TNC
0	4940	0	3472		3460		3215		2564		2596	
1	1527	1527	1702	2802	1413	1413	1409	1409	1087	1087	1139	1139
2	1098	2196	1211	2422	990	1980	931	1862	813	1626	817	1634
3	802	2406	923	2769	774	2322	748	2244	666	1998	592	1776
4	644	2576	883	3532	608	2432	628	2512	483	1932	461	1844
5	522	2610	700	3508	514	2570	532	2660	430	2150	103	515
6	418	2508	601	3606	445	2670	418	2508	385	2310	326	1956
7	384	2688	496	3572	382	2674	361	2527	361	2527	277	1939
8	355	2840	466	3728	332	2656	333	2664	290	2320	230	1840
9	295	2655	414	3826	280	2520	264	2376	255	2295	235	2115
10	241	2410	356	3560	254	2540	282	2820	214	2140	173	1730
11-20	1440	18956	2032	22692	1346	11234	1423	15810	1363	14058	1097	14026
21-30	606	14977	826	14189	590	9356	597	10259	558	8852	477	9894
31-40	281	8831	405	11376	277	7703	314	8697	287	5127	224	5345
41-50	179	7354	215	7932	181	5158	165	5536	143	6431	125	3678
51-100	275	17236	346	18494	286	13156	269	11666	261	11575	197	8238
> 100	97	17025	125	15684	100	17343	109	16576	79	16784	125	19362
Total	14104	108795	15173	123692	12232	87727	11998	92126	10239	83212	9194	77031

Average citations per paper is 7.85

4.3 Research Impact of Six IITs

The influence and visibility of a nation's research in global perspective can be measured through Relative Citation Impact (RCI). It is defined as "a country's share of world citations in the subspecialty/country's share of world publications in the subspecialty". "RCI = 1 denotes a country's citation rate equal to world citation rate; RCI < 1 indicates a country's citation rate less than world citation rate and also implies that the research efforts are higher than its impact; and RCI > 1 indicates a country's higher citation rate than world's citation rate and also imply high impact research in that country." These indicators have been used by (Dwivedi, et al. 2015)[12]and (Pradhan and Ramesh, 2017)[13-15] for assessment of organic chemistry research in India and Scientometrics of engineering research in IIT Madras and IIT Bombay.

The research impacts of six IITs are depicted in Table 4.3 which indicate that the RCI of three IITs are >1, meaning that the citations rate of three IITs is more than World citation rate and higher impacts in our country. IITB have highest RCI value (1.14) than other five IITs, IITR in the second position RCI value of (1.06) followed by IITKGP RCI value of (1.03), IITD RCI value of 0.98, IITM (0.91) and IITK have lowest RCI value of (0.88) among six IITs.

Table 4.3 Research Impact of Six IITs

Institutes	Total no. of publications	% of Total no of publications	Total no of citations (%)	Citations per paper	RCI
IITD	14104	19.34	108795 (19.0)	7.71	0.98
IITKGP	15173	20.81	123692	8.15	1.03
IITM	12232	16.76	87727	7.17	0.91
IITB	11998	14.03	92126	7.67	1.14
IITK	10239	16.45	83212	8.12	0.88
IITR	9194	12.61	77031	8.37	1.06
Total	**72940**		**572583**		

4.4 Highly Cited Papers

The authors whose papers are highly cited are presented here. The Table 4.4 exhibits 17 highly cited authors who received more than 500 citations. Out of the 17 highly cited authors 4 authors are from IITKGP, followed by 3 authors each from IITR, IITD and IITB, 2 authors each from, IITM, IITK. All the 17 papers attracted 17257 (2.66%) of the total citations. Out of 17 highly cited authors 8 papers were internationally collaborated, like Indian Science and Technology, where a noteworthy number of highly appreciated papers were with international collaboration. (Garg K C and Kumar S, 2013)[14] and (Pradhan, & Ramesh, 2017). Three papers were published by single author. It is also observed that more papers were published with multiple authors. Another interesting point noted here is that two articles of IITD published in one journal namely, Renewable and Sustainable Energy Reviews, and high IF journals received citations more than 1500 and 700 citations respectively.

Table 4.4 Highly Cited Papers

Sl. No.	Authors and bibliographic details	Title of Journal	TNC	Country of origin	Institute
1	Ravi Kumar, M.N.V.,	Reactive and Functional Polymers 46(1), 2000, 1-27	2095	The Netherlands	IITR
2	Klionsky, D.J., Abdalla, F.C., Abeliovich, H., (...), Zschocke, J., Zuckerbraun, B.	,Autophagy, 8 (4)2031, pp. 445-544	1673	USA	IITK
3	*Schnable, P.S., Ware, D., Fulton, R.S., (...), Wing, R.A., Wilson, R.K.,	Science 2009, 326(5956), 1112-1115	1567	USA	IITB
4	***Meher, L.C., VidyaSagar, D., Naik, S.N.,	Renewable and Sustainable Energy Reviews 10(3), 2006, 248-268	1536	UK	IITD
5	Agarwal, A.K.,	Progress in Energy and Combustion Science, 33(3), 2007, 233-271	1235	USA	IITK
6	**Ghosh, S.K., Pal, T.	Chemical Reviews 107(11), 2007, 4797-4862	1184	USA	IITKGP
7	*Gupta, V.K., Suhas,	Journal of Environmental Management 90(8), 2009, 2313-2342	1184	USA	IITR
8	***Bhardwaj, N., Kundu, S.C.,	Biotechnology Advances 28(3), 2010, 325-347	1064	USA	IITKGP
9	*Bond, T.C., Doherty, S.J., Fahey, D.W., (...), Warren, S.G., Zender, C.S.,	Journal of Geophysical Research Atmospheres, 118(11), 2013, 5380-5552	856	USA	IITB
10	*Naik, S.N., Goud, V.V., Rout, P.K., Dalai, A.K.,	Renewable and Sustainable Energy Reviews 14(2) 2010, 578-597	727	UK	IITD
11	*Bhadra, S., Khastgir, D., Singha, N.K., Lee, J.H.,	Progress in Polymer Science (Oxford) 34(8), 2009, 783-810	703	UK	IITKGP
12	***Chattaraj, P.K., Sarkar, U., Roy, D.R.	Chemical Reviews 106(6), 2006, 2065-2091	634	USA	IITKGP
13	***Gupta, K.C., Sutar, A.K.	Coordination Chemistry Reviews, 252(12-14),2008, 1420-1450	605	Netherlands	IITR
14	**Ruparelia, J.P., Chatterjee, A.K., Duttagupta, S.P., Mukherji, S.,	Acta Biomaterialia 4(3), 2009, 707-716	572	Netherlands	IITB
15	*Von Maltzahn, G.,	Cancer Research, 69(9), 2009,	559	USA	IITM

	Park, J.-H., Agrawal, A., (...), Sailor, M.J., Bhatia, S.N.,	3892-3900.			
16	*Dhillon, H.S., Ganti, R.K., Baccelli, F., Andrews, J.G.,	IEEE Journal on Selected Areas in Communications , 30(3) 2012, 6171996, 550-560	541	USA	IITM
17	Pandey, S.,	Analytica Chimica Acta 556(1), 2010, 38-45	522	Netherlands	IITD

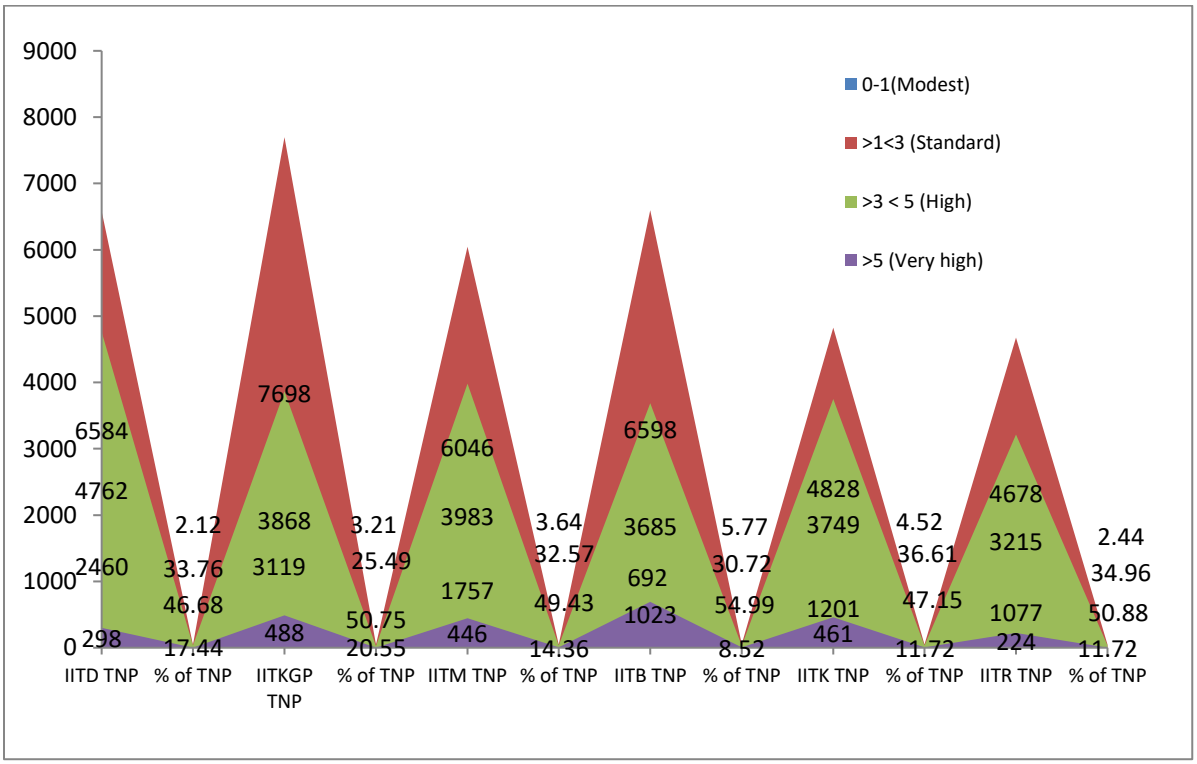
** International collaborative paper; ** domestic collaborative paper, *** Institutional collaborative paper (Author of one Institute)*

4.5 Distribution of papers according to impact factor

The impact factor is divided into four categories: those published in journals having "IF 0-1(Modest), those published in journals having IF>1<3 (Standard), those published in journals having IF>3 < 5 (High) and those published in journals having IF > 5 (very high)." Distribution of output according to the range of impact factor is given in Table 4.5, which shows that about less than one-fifth (8.52%) papers of IITB were published in lower impact factor journals followed by IITK (11.72%), IITR (11.73%), IITM 14.36 and IITD (17.44%). However, IITKGP published about one –fifth (20.55%) papers in lower impact factor journals. Of these, more than half (54.99%) papers of IITB were published in standard or medium impact factor journals closely followed by IITR (50.88%), IITKGP (50.75%). However, IITM, IITK and IITD published near about half of the papers in standard or medium impact factor journals i.e. 49.43%, 47.15% and 46.68% respectively. Rest, i.e. 41.13% papers of IITK, 37.4% of IITR, 36.49% of IITB, 36.21% of IITM, 35.88% of IITD and 28.7% of IITKGP were published in high and very high impact factor journals. Based on this criterion one can conclude that the output of six IITs is well connected with prime channel science as more than four fifth (91.48%) papers of IITB, 88.28 each of IITK and IITR, 85.64% of IITM, 82.56% of IITD of the published papers were appeared in standard, high and very high impact factor journals. The corresponding Figure depicts that highest numbers of papers of Six IITs are published in standard impact factor journals.

Table 4.5 Distribution of papers according to impact factor

IITs	0-1(Modest)	>1<3 (Standard)	>3 < 5 (High)	>5 (Very high)	Total
IITD	2460 (17.44)	6584 (46.68)	4762 (33.76)	298 (2.12)	14104
IITKGP	3119 (20.55)	7698 (50.75)	3868 (25.49)	488 (3.21)	15173
IITM	1757 (14.36)	6046 (49.43)	3983 (32.57)	446 (3.64)	12232
IITB	1023 (8.52)	6598 (54.99)	3685 (30.72)	692 (5.77)	11998
IITK	12.1 (11.72)	4828 (47.15)	3749 (36.61)	461 (4.52)	10239
IITR	1077 (11.73)	4678 (50.88)	3215 (34.96)	224 (2.43)	9194



4.6 Most common journals used for publishing research results

The primary source of information which has become the fastest and most effective means of disseminating research findings is the research journal. A higher emergence rate of periodicals in a subject field can be a measure of the growth of knowledge in that field. It is a recognized fact that in the field of science there is ostensibly an increasing rate of emergence of new journals to

meet the rapid explosion of information. The most preferred journals used to communicate research results are depicted in Table 4.6, which indicates that there remain differences in communicating their research results in journals. However, there are also some common journals in which six IITs publish their papers. These are Journal of Applied Polymer Science, Journal of Applied Physics, RSC Advances, Journal of Alloys and Compounds. A total of 7950 journals are used by the scientists of six IITs for communication research results.

Table 4.6 most used journals

Sl. No.	Journal Title	Journal publishing country	IF	No. of papers	Institutes
1	Physics of Plasmas	USA	1.93	163	IITD
2	Journal of Applied Polymer Science	USA	1.866	152	IITD
3	Journal of Applied Physics	USA	2.101	142	IITD
4	Journal of Applied Polymer Science	USA	1.866	140	IITKGP
5	RSC Advances	UK	3.289	123	IITKGP
6	Journal of Applied Physics	USA	2.101	119	IITM
7	Indian Journal of Fiber and Textile Research	India	0.42	115	IITD
8	Physical Review B Condensed Matter and Materials Physics	USA		114	IITK
9	Materials Science and Engineering A	Netherlands	2.647	111	IITKGP
10	Journal of the Textile Institute	England	0.94	109	IITD
11	Dalton Transactions	UK	4.177	109	IITB
12	Journal of Applied Physics	USA	2.101	107	IITK
13	International Journal of Heat and Mass Transfer	UK	2.857	106	IITM
14	Inorganic Chemistry	USA	4.82	106	IITB
15	Journal of Alloys and Compounds	Switzerland	3.014	104	IITKGP
16	Applied Physics Letters	USA	3.142	99	IITD
17	Journal of Applied Physics	USA	2.101	87	IITKGP
18	Industrial and Engineering Chemistry Research	USA		99	IITB
19	Inorganic Chemistry	USA	4.82	97	IITK
20	Applied Physics Letters	USA	3.142	91	IITB
21	Tetrahedron Letters	UK	2.347	90	IITK
22	Materials Science and Engineering A	Netherlands	2.647	88	IITM
23	Industrial And Engineering Chemistry Research	USA		84	IITK
24	Physical Review D Particles Fields Gravitation and Cosmology	USA	IF missing	84	IITM

25	Physical Review Letters	USA	7.645	83	IITB
26	Journal of Applied Physics	USA	2.101	83	IITB
27	RSC Advances	UK	3.289	79	IITB
28	Physical Review C Nuclear Physics	USA		77	IITB
29	Materials Science and Engineering A	Netherlands	2.647	77	IITKGP
30	Journal Of Chemical Physics	USA	2.894	77	IITK
31	RSC Advances	UK	3.289	77	IITK
32	Journal of Alloys and Compounds	Switzerland	3.014	75	IITKGP
33	Journal of Physical Chemistry C	USA	4.509	75	IITM
34	Journal of Alloys and Compounds	Switzerland	3.014	75	IITM
35	RSC Advances	UK	3.289	75	IITM
36	Physical Review E Statistical Nonlinear And Soft Matter Physics	USA		73	IITK
37	RSC Advances	UK	3.289	72	IITR
38	Advanced Materials Research	Switzerland		70	IITR

Conclusion: Thus, it has been seen that 72940 papers published by six IITs received 572583 citations in all during the period 2006-2015. The average citation per paper is 7.85 for all the six IITs. From the motif of citations it has been observed that scientific impact of all the six IITs is strongly linked to the mainstream science as more than four-fifth of the total productivity were cited in the international literature and highest numbers of papers of six IITs are published in standard impact factor journals.

References:

1. Saxena A Gupta, B M and Jauhari M., Research performance of top engineering and technological institutes of India: A Comparison of Indices, *DESIDOC Journal of Library and Information Technology*, **31**(5), 2011, 377-381.
2. Siddaiah Dinesh K, Gupta B M, Dhawan, S M and Gupta, R., Contribution and Citation Impact of Eight New IITs: A Scientometric Assessment of their Publications during 2010-14, *Journal of Scientometric Research*, **5**(2), 2016, 106-122.
3. Singh Y, Gupta B M and Kumar S., Research contributions and impact of research of Indian Institute of Technology, Roorkee, 1993 to 2001,*Annals of Library and Information Studies*, **52**(1), 2005, 8-14.

4. Pradhan, B. & Ramesh, D. B., Scientometrics of Engineering Research at Indian Institutes of Technology Madras and Bombay during 2006-2015. *DESIDOC Journal of Library & Information Technology*, **37**(3), 2017, 213-220.
5. Bornmann, L., Leydesdorff, L., & Wang, J., How to improve the prediction based on citation impact percentiles for years shortly after the publication date?. *Journal of Informetrics*, *8*(1), 2014, 175-180.
6. Ziman, John M., Public Knowledge: An Essay Concerning the Social Dimension of Science. Cambridge: Cambridge LJniversity Press, 1968, 58.
7. Narin, F., Evaluative bibliometrics: The use of publication and citation analysis in the evaluation of scientific activity, 1976, 206-219. Cherry Hill, NJ: Computer Horizons.
8. Malin, Morton V. "The Science Citation Index: A New Concept in Indexing." *Library Trends*, **16**, 1968, 376.
9. MacRoberts, M. H., & MacRoberts, B. R. Problems of citation analysis: A study of uncited and seldom-cited influences. *Journal of the Association for Information Science and Technology*, ***61***(1), 2010, 1-12.
10. Garfield, E., & Merton, R. K. (1979). *Citation indexing: Its theory and application in science, technology, and humanities* (Vol. 8). New York: Wiley.
11. Baird, L. M., & Oppenheim, C. Do citations matter? Journal of Information Science, **20**(1), 1994, 2-15.
12. Dwivedi, S., Kumar, S., & Garg, K. C.. Scientometric profile of organic chemistry research in India during 2004-2013. *Current Science*, ***109***(5), 2015, 869.
13. Pradhan, B. & Ramesh, D. B. Scientometrics of Engineering Research at Indian Institutes of Technology Madras and Bombay during 2006-2015. *DESIDOC Journal of Library & Information Technology*, **37**(3), 2017, 213-220.
14. Garg, K. C and Kumar, S. Scientometric profile of Indian science as seen through Science Citation Index Expanded 2010–2011, *SRELS Journal of Information Management*, **50**(5), 2013, 529–542.